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A survey of the insect fauna of the lowbush blueberry in Massachusetts : preliminary studies on the biology and control of the blueberry flea beetle (Haltica sylvia Mall.).

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A SURVEY OF THE INSECT FAUNA OF THE LOWBUSH BLUEBERRY IN MASSACHUSETTS.

PRELIMINARY STUDIES ON THE BIOLOGY AND CONTROL OF THE BLUEBERRY FLEA BEETLE (*Haltica sylvia* Mall.).

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by

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University of Massachusetts
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INTRODUCTION

The outbreak of the blueberry flea beetle in Massachusetts during 1947 and 1948 brought to light the need for controlling this pest and promoting study of its habits in this state. These flea beetle attacks also indicated the necessity for a general investigation into blueberry insect problems as a whole.

In Maine, where the blueberry is one of the more important cash crops, many years of study and work have been devoted to just such problems. It is hoped that this brief survey of the insects attacking blueberries in Massachusetts may instigate further research towards the development of the blueberry industry to a point of greater efficiency and value to the growers and the state as a whole.

The Blueberry Industry in Massachusetts

The lowbush blueberry growing business in Massachusetts is mainly centered in two areas. These are the Granville and Blandford area and the region around Ashburnham and Ashby. The exact total acreage is unknown, but an estimate of from 2500 to 3000 acres would probably be fairly accurate. The annual crop value is about $200,000. The Granville and Blandford area alone, is said to have had a $100,00 crop in 1948.

As in Maine, the lowbush blueberry is the most valuable one. Highbush plantings in Massachusetts cover much less acreage and their crops do not approach the value of the lowbush species in the commercial market.

In the latitudes of Massachusetts lowbush plants thrive best at higher elevations. Most of the better lots are found above an elevation of 1000 feet. Unshaded hill crown situations seem to offer the best sites as a maximum amount of sunshine is apparently required for vigorous growth. Each blueberry plant produces a large underground network of rhizomes from which the upright stems arise at frequent intervals. Each such network originating from a single parent plant, is known as a Clon.

The average lot in this state is composed of three different species of lowbush blueberry of the genus Vaccinium. In the order of their abundance they are pennsylvanicum Ait., myrtilloides Michx., and lamarckii Camp. Because all three of these plants grow side by side in individual clons a blueberry lot does not have a uniform cover. This is one of the reasons why insect infestations are usually found in localized areas even though the total area attacked may be large.

Most of the blueberry lots in Massachusetts were used as pastures before World War I. When they were abandoned the blueberries advanced into them and eventually became of commercial importance. The common practice has been to neglect the lot at all times during the year except to harvest the crop and burn the old growth out from time to time. Where the growers have begun to rely on the blueberry for a large part of their income they have instituted regular burning programs and other cultural practices.

The blueberry maggot (Rhagoletis pomonella Walsh) has long been considered the most important pest of this crop. Unlike many blueberry insects it is a constant pest from year to year. The blueberry flea beetle is fast becoming a rival in this category.

The Blueberry Flea Beetle; Description of Stages

Egg. The eggs are slightly elongate, orange in color, with polygonal areas entirely covering the surface. In length they average about one millimeter.

Larva. (Fig. 1) When newly hatched the larva is about one and a half millimeters long, shiny black in color. As it matures the color usually lightens to a brownish hue, becoming somewhat of a dirty yellow just prior to entering the soil as a prepupa. The length at larval maturity is about seven millimeters.

Pupa. (Fig. 2) When freshly formed the pupa is a conspicuous bright orange. As it approaches emergence the color darkens to gray or brown.

Adult. (Fig. 3) The adult beetle is a typical flea beetle with greatly enlarged hind femora adapted for jumping. The color is a brilliant metallic coppery-violet with greenish reflections. The claws are reddish-brown. Although variable, the length is about five millimeters.

For complete morphological description of all stages Bulletin 273 of the Maine Agricultural Experiment Station should be consulted.

Fig. 1. Mature flea beetle larvae.Upper: ventral aspect, lower: lateral aspect; 6 times natural size.(orig. photo by R. L. Coffin)

Fig. 2. Flea beetle pupa within pupal cell in the soil, 6 times natural size.(orig. photo by R. L. Coffin courtesy of J. S. Bailey)

Fig. 3. Dorsal aspect of adult flea beetle, 6 times natural size.(orig. photo by R. L. Coffin)

<u>The Blueberry Flea Beetle; Taxonomic Position</u>

Although all recent publications use *Haltica* (Altica) *sylvia* Malloch as the name of this insect, the exact nomenclature is in doubt.

It is a species of Chrysomelid bettle of the tribe Halticini, known as the Flea Beetles.

Woods (1918) first found this beetle feeding on blueberries in Maine and it was erroneously identified for him as *H. torquata* Le Conte. Malloch (1919) found on comparison with the type specimen from Kansas that the specimens collected by Woods and identified as *torquata* were pronouncedly different in their morphology from that species. He proposed that it be called *sylvia*, a new species.

The following year Fall, publishing in Psyche (1920), showed that both authors were wrong in their conclusions. He found that Blatchley (1910) had originally described it as *cuprascens* in his "Coleoptera of Indiana". Fall suggested that since *cuprascens* had priority, *sylvia* should be considered a synonym.

In spite of all this, the publications from Maine continued to call the blueberry flea beetle *H. torquata* Le Conte up to as late as 1936, Lathrop, (1936). All later publications use *H. sylvia* Malloch. *H. sylvia* is also used in recent publications from other sources.

Thus, although there is seemingly no other word published on the subject since that of Fall in 1920, the misnomer *H.*

sylvia has continued to be in use.

In a recent letter to Dr. F. R. Shaw of the Department of Entomology at the University of Massachusetts, C. F. W. Muesebeck (in charge of the Division of Insect Identification, U.S. Bureau of Entomology and Plant Quarantine) states that there is some uncertainty as to the correctness of the synonomy of sylvia with cuprascens.

In answer to an inquiry by the author, C. A. Frost, considered to be an authority on such subjects, said that he knew of no authority for H. sylvia. He went on to say that it was his opinion that the genus was in very doubtful condition as a whole, but if Fall was right in his conclusions, then cuprascens is the proper designation and sylvia is a synonym.

REVIEW OF LITERATURE

There is only a small amount of published material on the subject of blueberry insects. This is especially true for lowbush blueberry. The bulk of all the work done in this field has been performed in Maine where the most extensive production of blueberries occurs. Therefore, nearly all of the references cited in this work are from Main Agricultural Experiment Station bulletins.

Other states publishing on lowbush blueberry problems are New Hampshire and Vermont, but, very little insect data have been found in any of the publications available to the author from these states. The Dominion Department of Agriculture of Canada could supply but one bulletin in which the insect problem was treated. The "Canadian Entomologist" yielded but one reference.

For the state of Massachusetts there is only one reference dealing strictly with lowbush pests. This is the unpublished manuscript of Shaw (1948) based on his investigations carried on during the summer of 1948.

"Cape Cod Cranberry Insects" by H. J. Franklin (1928), and "Cranberry Insects in Massachusetts" (1948) by the same author provided several references.

Since there exists such a great ecological and physical difference between the low and the highbush blueberry, control methods used for insects which occur on both types have not been cited from publications dealing with highbush only.

Blueberry Flea Beetle

The blueberry flea beetle was first noticed feeding on blueberries by Woods (1918) who deemed it to be a serious pest in Maine in years during which it became abundant. He reared it and it was erroneously identified as *Haltica torquata* Le Conte, (as discussed in the previous section). He found that, unlike other flea beetles of that region, it did not over-winter as an adult but passed the winter in the egg stage. Woods found that the larvae appeared as early as May 24th in Maine, all but a few of the larvae of the annual generation pupating before the end of July. This places the first hatching in the spring about two weeks later than in Massachusetts.

Wood states that the beetle is widely distributed in Maine. He took it in four different counties. Though normally quite rare in the state, it periodically occurred in great numbers, especially in Washington county where over 250,000 acres of blueberry land is concentrated. It was very abundant from 1914 through 1917 and then almost disappeared in 1918.

The flea beetle larvae were said to devour first the blossom and then attack the leaves. The writer believes that the leaves are attacked first.

The food plant other than blueberry eaten by the adult was red oak (*Quercus rubra* L.). Forty-six other species of plants common to the distributional area of the insect were refused. The larvae ate red oak and also wild plum(*Prunus nigra* Ait.).

Phipps (1930) agreed with the observations made by Woods on the biology of the flea beetle in Maine. He found it to be "by far the most abundant and injurious beetle" encountered during his studies on blueberry pests.

The Main Agricultural Experiment Station has noted several serious outbreaks of flea beetle since Woods' original observations. In addition to the 1930 outbreak, Phipps also notes outbreaks in 1925 and 1926. Later outbreaks were in 1935, (Lathrop, 1936); one in 1945 (Lathrop and Hawkins, 1946); and another in 1946(Lathrop and Knight, 1947).

In Canada, Maxwell and Pickett (1949), report that flea beetles were prevalent throughout southern New Brunswick in 1947, and caused extensive damage to the crop.

Woods (1918) thought that control could be obtained by using arsenate of lead against both the larvae and adult, although he had not undertaken any control experiments. He believed that the practice of periodic burning of lots would destroy most of the eggs. All subsequent control recommendations for Maine include burning as an important factor in keeping the insect in check.

Phipps (1930) recommended lead arsenate, 1½ pounds in 50 gallons of water. To this mixture was added 2 pounds of soap. Lathrop (1936) obtained good early season control with a calcium arsenate dust. In recent years DDT has become the primary insecticide used against flea beetle on blueberries. Lathrop and Knight (1947) used a 5% DDT dust against young larvae with good results. Later in the season when larvae were larger the same treatment gave results which were considered unsatisfactory. The same findings are noted by Lathrop (1949) in Maine where it is stated that,"If the application is delayed, the damage may be great and the insects, as they grow, become increasingly difficult to kill."

The Maine dust program for 1947 recommends 3 to 5% DDT dust at 10 to 20 pounds per acre for larval control, (Anon., 1947). This 1947 program recommends a 50-10-40 calcium arsenate, monohydrated copper sulphate and hydrated lime as a dust against the adult beetles. The same control schedule was continued in 1949.

In Canada, Maxwell and Pickett (1949) suggest 3% DDT dust at a rate of 30 pounds to the acre. They found that the first blueberry maggot application of 6 pounds of arsenate of lime per acre was entirely satisfactory for the control of the adults. Some of the difficulties encountered in controlling the flea beetle that were mentioned by the same authors were that it was difficult to find infestations in time for adequate control methods, and also that it was sometimes necessary to continue control operations into blossom time in some areas. The latter is, of course, very undesirable because insecticides applied to open flowers will kill many bees, and pollination and subsequent yield will be reduced. The dust programs for Maine in 1947 (Anon., 1947) and 1949 (Lathrop, 1949) point out that no insecticide of any type should be used on open flowers for the above reason. It might be pointed out that after the flowers have been open for several days pollination usually has been completed and little harm can result to the yield if such older blossoms are treated. During the course of the experiments discussed later it was found very necessary to treat a large area of blueberries which had been in blossom for about a week. This treatment killed the flea beetle larvae and presumably killed many bees or repelled them from the blossoms, yet the yield over this area was very good.

According to Shaw (1948), the blueberry flea beetle was first brought to the attention of Massachusetts entomologists in 1947. A heavy infestation in the Granville and Blandford area was called to the attention of the state and an investigation followed. As this 1947 infestation was noticed too late in the year for very much observation or experimentation, the work was carried over into the next growing season. Shaw found the 1948 outbreak to be severe and widespread.

In 1948, Shaw found an adult beetle on the tenth of June. This, coupled with the findings of hatched eggs in the humus about the base of blueberry plants and the presence of an adult beetle in late October lead him to doubt if the species over-wintered entirely as an egg as reported by Woods (1918).

Control experiments with the adult beetles were carried out. Shaw found that 5% DDT dust, 1% parathion dust, and a commercial preparation of tetra ethyl pyrophosphate were all very toxic to them. Parathion and TEP gave a considerably faster knockdown than DDT. He does not make mention of larval control.

Shaw also reports that efforts to induce copulation or oviposition under laboratory conditions were completely unsuccessful.

The Blueberry Maggot, (Rhagoletis pomonella Walsh)

The blueberry maggot is a race of the apple maggot or "railroad worm" which has become physiologically distinct from its apple infesting relative. The adult flies are only about half the size of the adult apple maggot but are otherwise morphologically identical to them. All attempts to induce the blueberry strain to oviposit in apples, or the apple strain to oviposit in blueberries have failed. Patch and Woods (1922) made an extensive series of tests with both races in the Maine blueberry regions, all of which were unsuccessful. In another report on the maggot Phipps (1930) mentions similar failures in such attempts. Larvae of either strain, when introduced into the host fruit of the other failed to complete development in all cases reported by Patch and Woods (1922) and Phipps (1930).

There is but one generation a year. Patch and Woods (1922) and also Phipps (1930) reared the larvae from three varieties of lowbush blueberry. In order of preference they are V. pennsylvanicum Ait., V. canadense (myrtilloides) Michx., and V. vacillans Torrey. Other common hosts are snowberry

(Symphoricarpus racemosos Michx.). Patch and Woods (1922) refer to an uncited reference of successful rearing attempts with this plant. In the same publication Patch and Woods report that in chokeberry (Pyrus melanocarpa Michx.) they were unable to find any infested plants in the field but were able to introduce partially grown larvae into the ripe berry and carry them through to adults. Phipps (1930) found heavy natural infestations in chokeberry working in the same area in Maine as Patch and Woods. Another important host species mentioned by him is huckleberry (Gaylussacia sp.). Patch and Woods also found maggots to be numerous in the fruit of the Juneberry (Amelanchier spicata (Lam.) C. Koch).

Beckwith (1943) states that one percent infested berries in a pack would render it worthless for fruit or processing. Patch and Woods (1922) found that seven percent of the berries they had collected at random contained maggots. Phipps (1930) points out that as the result of several large shipments of Maine blueberries being condemned for interstate shipment in 1924 the Federal government established a tolerance of fourteen maggoty berries per pint can. As a pint of processed blueberries contains several hundred berries the need for adequate control and better culling methods became highly important. He describes demaggoting cylinders which are revolved at a rate of twelve revolutions per minute to burst the softer, infested berries. The broken berries are washed free of the maggots as they pass through a shallow bath of running water. He further states that, although efficient in removing the maggots, this method is somewhat damaging to the berries due to loss of juice, shrinkage, and bruising.

Patch and Woods prescribed an eight point control program.

1. Early canning and harvesting to avoid over-ripe fruit which is more attractive to the pest.

2. Speed in handling the fruit to kill the unhatched eggs which, being very small, are unobjectionable.

3. Destruction of maggots in the fruit by collecting and destroying all berries which remain after the commercial picking is done.

4. Destroying pupae in the soil by frequent burning of the blueberry lots and adjacent improved land.

5. Preventing the adults from ovipositing by burning over the land or plowing under the plants. There are no berries produced during the first season following a burn.

6. Clean picking. This supplements the method in point 3 by picking the non-commercial berries and seeking out the stray patches in bordering areas which were not covered by the pickers during the regular harvest.

7. The destruction of wind breaks in the blueberry lots. There is evidence to indicate that windy situations are less frequented by the flies.

8. Destruction of waste at the cannery to prevent culled maggots from maturing.

Calcium arsenate was recommended by Phipps (1930). He reported that two dust applications gave 80-90% reduction in maggoty fruit. Experimental dusting with airplanes was tried but deemed too hazardous. Calcium arsenate used at a rate of six pounds per acre was found to be superior to several non-arsenical insecticides in reducing the number of maggoty berries in a Maine lot, (Anon. 1942). A 2% rotenone dust gave equally effective control and was also less injurious to the plants than the calcium arsenate.

Lathrop, Plummer, and Dirks (1944) found that rotenone compared well with calcium arsenate, but a copper-lime calcium arsenate dust was superior to both in killing the flies and gave less plant injury than plain arsenate dust. The same control was noted by Lathrop and Hawkins (1946), and Lathrop and Knight (1947).

In Canada a program of two sprays of calcium arsenate dust was found to give better control than 3% DDT dust, (Anon. 1945). Lathrop et al (1948) found that DDT used for maggot control caused a reduction in yield, although causing no apparent damage to the plants at the time of application. Again in Canada, Maxwell and Pickett (1949) give much the same recommendations for maggot control as given above, with a suggested single treatment by hand duster using lead arsenate for small infestations. The insecticide is to be applied when first berries turn blue.

The most recent program for the control of blueberry maggot in Maine depends upon the use of a 50% calcium arsenate, 10% monohydrated copper sulphate, and 40% hydrated lime dust preparation applied at a rate of 6 pounds to the acre (Lathrop, 1949) and (Anon. 1949).

Blueberry Thrips, (Frankliniella vaccinii Morgan)

The blueberry thrips was first described from lowbush blueberry specimens collected by Phipps while working in

Maine. The first adults appear during the first week of July and the second generation nymphs are first found ten to fourteen days later. By the latter part of August all the thrips have left the plants to over-winter in the soil. The preferred food plant is reported by him to be V. pennsylvanicum Ait.

Phipps found the blueberry thrips very hard to control with nicotine sulphate sprays or dusts, a nicotine sulphate and lube oil emulsion, or with spring burning. He reported the successes of some growers who burned the infested area during June. This prevents reinfestation the following year. (There are two drawbacks to this system, the obvious one being the destruction of part of the crop, the second being the difficulty in securing burning permits at that time of year.)

Since its first outbreak, the blueberry thrips has reappeared many times in the blueberry country of New England and Canada. Lathrop (1942) also reports it in Wisconsin. Maxwell and Pickett (1949) report heavy infestations in the New Brunswick region. Twelve percent of the new growth was affected, and one large blueberry barren was thirty-five percent affected. They found it to be confined to the variety V. pennsylvanicum Ait. There are no control methods known in Canada.

There has been no adequate control found for this pest. Lathrop (1936) tried derris dust, equal parts derris and sulfur dust, sulfur dust, 3% nicotine dust, and flake napthalene with no success. In 1942, (Anon. 1942), a kerosene-water emulsion applied to the soil while the thrips were still dormant was found to give good control, but the cost of kerosene used at a rate of one pint per square yard is not economically suited for control over large areas. Lathrop (1945) failed to obtain satisfactory results with high concentrations of 5% DDT dust on either the hibernating forms or the active feeders. The same author, working with Knight, (1947), used Benzene-hexachloride on dormant forms in the spring but reported negative results. Again in 1948, Lathrop (1948) used Benzene-hexachloride and DDT on active thrips but found these insecticides to effect no appreciable reduction in the population. Further investigations are now being carried on in Maine, (Anon. 1949), with the use of DDT and Chlordane receiving most of the attention.

The Chain Dotted Measuring Worm, (*Cingilia catenaria* Dru.)

Although it has not been abundant in Maine for several years, this pest occasionally occurs in great numbers. It is primarily a pest of cranberries (also *Vaccinium*). Franklin (1928) stated that it is drawn to the cranberry growing areas by the presence of gray birch, (*Betula populifolia* Marsh). Phipps (1928) stated that his observation of this insect feeding upon blueberry was the first time it had been recorded as a serious pest of that plant. It has been recorded on a total of forty-seven different plant species, including three blueberry species.

Phipps, traced the life history and the feeding habits in the same publication, (1928). The larvae is a slow growing one which, in Maine, spends the whole season feeding. The adults emerge late in the fall and lay eggs which hatch the following spring. The larvae feed not only on the leaves and defoliate the plants, but also feed on the berries when they ripen. The eggs are deposited singly on the undersides of leaves, primarily on sweet fern (Myrica asplenifolia L.).

Phipps (1928) recommended a lead arsenate spray for the control of this pest. In Canada, where there are also occasional outbreaks, Maxwell and Pickett (1949) recommend a dust composed of 70 parts gypsum or talc and 30 parts cryolite to be applied immediately upon discovery of the infestation. Also recommended is a lead arsenate spray, and possibly a DDT dust.

The Black Army Cutworm, (Actebia fennica Tauscher)

This pest, which is primarily a night feeder, was first found on blueberries in 1925. Phipps (1927) reported an estimated loss of approximately $100,000 in the first invasion on blueberries in Maine. He believed that it only attacked areas of new burn, second growth being ignored.

Black army cutworm larvae feed on the developing buds, usually making their initial ingress on the higher portions of a blueberry lot. In the 1927 paper, Phipps stated that he believed the numerous reports of peculiar frosts occuring only on hill summits and ridges were actually caused by the nocturnal feedings of this insect.

Phipps (1927) and Maxwell and Pickett (1949) say that the usual overwintering form is young larvae, but they also think that some eggs over-winter.

According to Lathrop (1945) the first severe outbreak of this cutworm in the Maine barrens since 1925 occured in 1944 and 1945. The infestation was noticed early in April and damage had become heavy by the 10th of the month. The best measure found during this outbreak was a 3% DDT dust. It was superior to paris green bait, calcium arsenate dust, cryolite dust, and copper-lime and calcium arsenate dust. By 1946 the pest was on a decline in Maine (Lathrop and Hawkins, 1946). By 1947 there was no injury reported (Lathrop and Knight, 1947).

Maxwell and Pickett (1949) record the black army cutworm as occuring in much the same manner in Canada as it does in Maine. They recommend sweeping the fields at night with an insect net to determine the extent of their numbers. Any count above twelve larvae per 50 sweeps is considered sufficient to warrent control measures. They find that 30 pounds of 3% DDT dust per acre applied as soon as possible upon finding larvae gives good control. The current program in Maine (Lathrop, 1949), calls for 5% DDT dust at 10 to 20 pounds to the acre.

The Blueberry Leaf-Beetle (Galerucella vaccinii Fall)

Although it has not appeared in serious concentrations in a number of years, this insect has caused considerable damage in the Maine blueberry fields in the past. It is considered important enough for inclusion in the latest blueberry dusting schedule for that state. (Lathrop, 1949). A 5% DDT dust is recommended for use against the larvae, and a 20-20-60 calcium arsenate, monohydrated copper sulphate, and hydrated lime dust is used against the adults.

The beetle was first described by Fall (1924) from specimens taken feeding on blueberries in both Maine and Massachusetts. There is one generation per year. The adults hibernate during the winter and accomplish copulation and oviposition the following spring. He reported that the bulk of the eggs were deposited during the end of June and the beginning of July.

Insect Species Attacking Lowbush Blueberry

Because many publications fail to state whether the blueberries discussed are low or highbush species, only those insects which are definitely stated as occuring on lowbush are included in this paper.

With the exception of the mealybug Phenacoccus flaveola (Ckll.) which was found by F. R. Shaw in a Massachusetts lot in 1948, all the species found in the literature are recorded in Phipps' "Blueberry and Huckleberry Insects", (1930). No additional species have been reported in any source since that date.

The following is a list of the species attacking lowbush blueberry. All of those taken by the author are distinguished by either a single or double asterisk. A single asterisk (*) indicates previously reported species and a double asterisk (**) indicates species herein recorded for the first time.

An annotated list of all species collected by the author begins on page 47.

Orthoptera

Camnula pellucida (Scudder)
Chloealtis conspersa Harr.
Chorthippus curtipennis (Harr.)
**Chortographa viridifasciata (DeGeer)
Dissosteira carolina (L.)
Melanoplus bivittatus (Say)
Nemobius fasciatus (F. Walker)
Nomotettix cristatus cristatus (Scudder)
**Oecanthus niveus DeGeer
*Pardalophora apiculatus (Harr.)
Phaneroptera curvicauda borealis (Hebard)
Phaneroptera pistillata (Brunner)

Hemiptera

*Adelphocoris rapidus (Say)
**Banasa dimidiata (Say)
*Chlorochroa uhleri Stal.
Coenus delius (Say)
Euschistus euschistoides (Voll.)
**Euschistus variolarius (Palisot de Beauvois)
**Ischnorhynchus resedae (Panzer)
Ligyrocoris sylvestris L.
Lopidea instabilis (Reut.)
*Lygaeus kalmii Stal.
**Mormidea lugens (Fab.)
Nabis rufusculus Reut.
Nysius ericae (Schill.)
Parthenicus vaccinii (Van D.)
**Phlegyas abbreviatus (Uhl.)
Platytylellus rubrovitattus (Stal.)
Sixeonotus albohirtus Knight
Sphaerobius insignis (Uhl.)

Homoptera

Cicadella gothica (Sign.)
*Clastoptera proteus Fitch
Deltocephalus myscellus Ball
Euscelis vaccinii (Van D.)
**Gypona cinerea Uhl.
Gypona octolineata Burm.
**Gypona scarlatina Fitch
**Lepyronia quadrangularis Say
Oncometopia lateralis (Fab.)
Phenacoccus flaveola (Ckll.)
**Philaenus spumarius Sp.
**Xerophloea major Baker

Thysanoptera

Aelothrips sp.
*Frankliniella vaccinii Morgan

Coleoptera

**Anthonomus musculus Say
**Anthomus rubidus Lec.
Aserica castanea Arrow
Bassareus formosus Melsh.
**Cardiophorus convexulus Lec.
*Chlamys plicata
**Chrysodina globosa (Oliv.)
Cryptocephalus venustus Fab.
Galerucella vaccinii Fall.
**Graphops curtipennis Melsh.
*Haltica sylvia Mall.
**Paria canella (Fab.)
Pseudanthonomus validus Dietz
Serica vespertina Gyll.

Diptera

Dasyneura cyanococci Felt.
Drosophila melanogaster Meig.
Lasioptera fructuaria Felt.
*Rhagoletis pomonella Walsh

Lepidoptera

**Abbotana clemataria (S. and A.)
Actebia fennica Tauscher
Acronycta distans Grt.
Agrotis bicarnea Gn.
Agrotis c-nigrum L.
Agrotis rubifera Grt.
Agrotis phyllophora Grt.
Amphidasis cognataria Gn.
*Cingilia catenaria Dru.
Crambus hortuellus Hb.
*Drasteria graphica atlantica B. and McD.
Dolba hylaeus Dru.
*Epiglea apiata (Gn.)
*Euchlaena serrata Dru.
Feltia ducens Wlk.
*Gelechia trialbamaculella Cham.
*Glena cognataria Hbn.?
Hyppa xylinoides Gn.

Lepidoptera (continued)

Itame brunniata Thun.
*Itame inceptaria Wlk.
Itame pustularia Hb.
Itame ribearia Fitch
**Itame sulphurea (Pack.)
Lampra brunneicollis Grt.
Lycophotia astricta Morr.
Lycophotia margaritosa Haw.
Noctua clandestina Harr.
Paonius astylus Dru.
Papilio glaucus turnus L.
Polia detracta Wlk.
Polia subjuncta G. and R.
*Porthetria dispar L.
Schizura unicornis S. and A.
Scopelosoma walkeri Grt.
Sphinx canadensis Boisd.

MATERIALS

Insecticides and Equipment

Parathion was chosen for control experiments for a variety of reasons. Results from Maine where DDT has been the primary means of controlling the flea beetle have shown that a reduction in the size of berries and the amount of yield may be directly attributed to the use of that insecticide. Also, as in many fruit crops, the amount of residue left by the DDT is undesirable. In addition to these reasons DDT has shown an inability to control the late larval stages of the insect. For these reasons Parathion was selected as a logical replacement for DDT. It has considerably less residual toxicity than DDT and is also a very powerful insecticide.

The American Cyanamid Company supplied samples of Parathion 25% wettable powder and 0.5% and 1.0% dusts. The DDT dusts, which were put on by the growers themselves in independant applications, were standard commercial 5% dust preparations.

Spray and Dust Equipment

Plot tests were sprayed with a 5 gallon knapsack compressed air sprayer with a fine spray attachment. Where plots were dusted a hand powered crank type portable duster with one blower outlet was used. These kinds of hand powered portable equipment are often adequate for treating spot infestations if they are not too extensive.

Large scale applications of the wettable powder were applied with a 500 gallon capacity orchard spray rig equipped with a heavy rubber hose about 100 feet long at the end of which was the spray nozzle. The rig was hauled over the rugged terrain of the lot with a small caterpillar type tractor. A coverage of about 100 feet on either side of the tractor and rig was obtained by using the hose up to its full length. The use of a long hose such as this allows good coverage of the lot with a minimum of plant destruction from running heavy equipment over it.

A late model blower type orchard duster was used to apply the dust formulations. Both the Parathion and the DDT dusts were put on with this machine. As this duster was designed more for overhead work than use on a field crop, the efficiency of application left something to be desired, but as both the DDT and Parathion dusts were applied with this same blower, the differences, if any, between the two insecticides should not have been affected.

In petri dish tests against late instar larvae an 85-15 lead arsenate-sulfur dust was used.

Collecting and Rearing Equipment

All insects were collected with a 10 inch butterfly net. In sweeping, those insects which were not wanted for rearing were placed in a cyanide jar and killed. Later the dead insects were stored in paper triangles until they were mounted.

Soft bodied insects were placed directly in small vials of preservative alcohol after they had been killed. Insects which were collected in the larval stage were placed in jars containing blueberry leaves if they were to be kept for rearing, they were then transfered into a rearing chamber when they were brought back to the laboratory. Two plots of blueberry plants were maintained outside Fernald Hall from which fresh material for the rearing procedures was obtained.

Rearing Chambers

The first rearing efforts were undertaken in the greenhouse. The cages were 12 inches square and 20 inches high with a full length door on one side. Three or more sides were cheesecloth in order to provide ventilation. Each cage contained a wooden flat in which was placed a block of soil containing blueberry plants just as they had come from the field. The insect to be reared was placed upon the plant. Plants were watered from time to time with a dipper full of tap water. Each cage was tagged with the pertinent collection data.

Later rearing work was carried on in jars of quarter and half pint size. A small layer of soil was placed in the bottom of each jar and kept in a moistened state to humidify the chamber. Most of the soil used came from a blueberry lot. Fresh sprigs of blueberry leaves were placed in each jar daily. The final rearing chamber decided upon was simply an empty jar of the sizes already mentioned. Plant material was supplied as before. A piece of water soaked paper toweling was placed in the lid to supply the proper moisture and replenished when necessary. All rearing which was done in jars was carried on in the laboratory at room temperature.

The data obtained from the insecticidal applications and the rearing and collection of insects was recorded in a notebook from day to day.

METHODS

Beginning in the last week of April, bi-weekly trips were made to the blueberry growing areas. During these trips several lots were usually visited. When certain data had to be derived in the field, visits were made as frequently as deemed necessary. The majority of the work was done in the Granville and Blandford area in the Southwestern portion of the state. Several visits were made to the Ashburnham and Ashby region near the New Hampshire border and a lot in Westhampton was checked for flea beetle and collected from a number of times. One visit was made to a lot in Westminster. The field work was concluded in the middle of September.

Much valuable information on past insect infestations and experiences with control efforts was obtained in conversations with the growers during these visits.

Collection and Observation of the Flea Beetle

Observations of the flea beetle were made under a variety of conditions. Their reactions to weather conditions and molestation were determined by inspection at close range. To determine their rate of migration an area was swept clean of larvae and marked. Subsequently the marked area was revisited and the extent of the greatest penetration of the swept area was taken as an index of the rate of movement measured in number of feet per day.

Observations on the feeding habits were made both in the field and the laboratory. In rearing the larvae in cages with living plants the feeding habits of each instar were investigated.

Data on the life cycle were taken from rearing experiments and correlated with the cycle in the field. To ascertain the stage in which the insect passed the winter a cage made of wire screening was placed over a plot of transplanted blueberries on the south side of Fernald Hall. Into this cage, which was three feet high and three feet square, over a hundred adult flea beetles were placed in the Fall of 1948. In the spring of 1949 this cage was watched closely to see whether any adults had overwintered or there had been eggs layed in the fall which would hatch when the weather warmed up.

Population counts in the field were made by using a standard sweep of the 10 inch net. The number of larvae per sweep was used as an index of the numbers of larvae present. Amount of damage to the blueberry plants was estimated by inspection of the plants over the infested areas. Counts of adult beetles were made in the same manner, although the damage to the plants was not as readily determined due to the previous larval damage to the same area.

Data on the reduction of yield due to the flea beetle were taken by harvesting the crop on the insecticide test plots and comparing it with the check plot which was not treated. The fruit on each plot was harvested with a blueberry rake and measured out into quart baskets. Results are shown in Table 3. An incidental observation of 100% reduction was made on a farm near Ashburnham.

Most of the observation of caged flea beetles was done on the larvae. The cheese cloth walled chambers mentioned previously were used exclusively. The larvae were brought in from the field and placed in the cage and checked every day. The type of damage, manner of feeding, and the change of habits as they matured were noted.

Collection and Observation of the Blueberry Maggot

The adults of the blueberry maggot were first taken in routine sweepings in mid-summer. The appearance of these first forms was recorded, as their annual time of emergence is important in their control. Subsequently, the population density of the flies was noted on each collecting trip. Counts of maggoty berries during harvest time were made by checking through several quart boxes taken at random from the various berry sheds of the growers where the fruit was packed. All soft berries found in the box were put aside and split open with pressure of the fingers. The number of maggoty berries per box was divided into the total number to derive the percentage of infestation. On hybrid "half-high" plants a sample of a hundred berries, more or less, was taken and checked through for maggots. These hybrid plants are usually not harvested because of the extremely dark color of the fruit and somewhat early ripening period.

Collection and Observation of Other Insects

The larvae and adults of the other insects which were found feeding upon the blueberry plants or which obviously congregated in the berry lots, were collected at random, unless they were present in large enough numbers to warrant an individual population count. Specimens of each species were killed and preserved for identification. The actual identification of species was made with the aid of various publications on blueberry insects, mostly Maine Experiment Station bulletins, and some from regular insect keys for special groups.

Where possible, the type of damage to the crop was noted for each species. Where the insect was observed in the field the damage was observed directly, otherwise the insect was placed in a rearing chamber and the feeding habits observed in the laboratory.

The first rearing cage used on these insects was the same as used for the flea beetle. This cage type had to be abandoned for three reasons: (1) because of the large number of different species which had to be reared there were not enough cages, (2) there was a very high mortality rate among the larvae placed in these cages, and (3) insects were not sufficiently isolated and small larvae were difficult to observe in such a large cage.

The next method tried was to place the larvae in a quarter or half-pint jar with sufficient moistened soil in the bottom to provide the necessary humidity and a place to pupate. Fresh blueberry stems were provided each day. This method was modified when it became obvious that very few larvae matured because they were attacked by mold. On the assumption that the mold spores were present in the soil used in the jar, it was decided that a sterile soil should be used.

To obtain a sterile soil each batch to go into a rearing jar was first placed in a small tin box and cooked over a bunson burner. Either this method was not efficient in destroying the mold spores, or the soil was not the source of the mold, for with treated samples of soil the same losses due to mold were found as before.

The final rearing chamber consisted of the same kind of jar as used previously but without the soil. To humidify the chamber a piece of paper toweling was put into the lid and kept moistened. When the insect was ready to pupate a pad of dry toweling was placed in the bottom of the jar. This kind of rearing chamber was the most successful one tried.

Control Experiments on the Blueberry Flea Beetle

To determine the value of Parathion in controlling the blueberry flea beetle, two test plots and one check plot were laid out. The three plots were placed in an area where the plant cover was as uniform as could be found. Plot "A" was 30 feet square. On this was sprayed approximately two gallons of a wettable powder water solution made by mixing 25% wettable powder at a concentration of $1\frac{1}{2}$ pounds to 100 gallons of water. Plot "B" was 40 feet square. It was dusted with 2 pounds of 0.5% dust material, which is equivalent to 54 pounds per acre, or 27 pounds per acre of 10% dust. This was the lightest possible coverage which could be had with the hand duster. Plot "C" was left untreated as a check plot. It was 30 feet square.

Each plot was swept with the net before the insecticide was applied and a record of the concentration made. It was necessary to make a number of sweeps over each plot, so each netful of larvae was carefully dumped back onto the area from which it had been taken so that the natural distribution would not be disturbed.

Approximately 50% of the larvae were in their final instar when the tests were made. The plots were checked almost daily until this condition came about, as it was desired to have many of the larvae in the last instar. This was done because DDT does not give good results on these older larvae and a comparison was desired.

The three plots were swept at the end of three days. During this period there had been no rainfall and the weather was clear. The concentrations were obtained as before and the percentage of kill calculated by comparing the pre-test population with the post-test population. Results are shown in Table 1.

In other field control experiments an area where the larval count was high was marked with a stake driven into the ground on which was tied a tag containing the data for that spot.

After the portion of the lot which contained the markers had been treated, another count of the larvae was made and compared with the original count. This was done where 5% DDT dust and Parathion dust and spray had been applied by regular methods on a large scale. In this manner some idea of the relative effectiveness of the actual overall control was obtained.

Petri Dish Tests

When DDT seemed to lack effectiveness on later instar larvae, a series of petri dish tests were run. In actual control work done in 1948 good results were reported with a DDT and lead arsenate dust formulation. Because straight 5% DDT was apparently less toxic than the DDT and lead combination, a comparative test between DDT and an 85-15 sulfur and lead arsenate dust was made.

In the Petri dish tests 25 late instar larvae were placed in each dish. A small layer of moistened soil, all from the same source, covered the bottom of each dish to provide humidity and natural conditions. Two groups of dishes were run consecutively, three dishes per test. A number of blueberry leaves from the stock plantings were then selected. All of these leaves were taken from the same parts of the stems from which they were picked and were of approximately equal size and quality. Five leaves were shaken with a 3% DDT dust and blown free of excess particles and placed in the first dish. Another group of five leaves was treated with 85-15 sulfur-lead dust and placed in the second dish. Five untreated leaves were placed in the third dish to serve as a control for the experiment. Observations and counts were made at six hours, 24 hours, and 48 hours. At the end of the 48 hours a mortality count was made in each dish. The second test was made in the same manner using 5% DDT dust instead of 3%. Results are shown in table 2.

RESULTS AND DISCUSSION

Biological Observations on the Blueberry Flea Beetle

Time of Hatching and Period of Larval Activity

On the 25th of April, 1949, the first very young flea beetle larvae were found. They were present in small numbers on the south slope of a hillside lot in Granville Center. These larvae were collected and brought into the laboratory and identified by comparing them with some alcoholic specimens. By their measurements they were found to be very early first instar, probably not more than a day or two from the egg. A point worthy of consideration is that the weather immediately preceeding the discovery of these larvae was the first prolonged, warm, sunny spell of the spring. Emergence time probably depends very much on the weather conditions and will vary from year to year. Larvae were found to be abundant by Shaw (1948) as late as June 10th the year before, whereas nearly all larvae had pupated by the end of May in 1949.

The first larvae were found feeding on plants still in the late dormant stage. Hatching continued into about the middle of May, by which time all plants had leafed out and some blossoms had opened.

Of the six lots inspected during the three weeks following the initial hatching, five were found to have flea beetle larvae. The end of this three week period marked the approximate peak of the infestation. Concentrations of larvae varied from a low of one or two per sweep of the net, to about one hundred per sweep.

Feeding Habits

As the blueberry plants began to leaf out, the evidence of damage from the larvae became obvious. Those attacked at this stage were devoid, or nearly devoid, of all leaves and such an area could be readily singled out from the unharmed regions. The tender leaf buds and young leaves had been eaten down to the stem and all that remained were the terminal blossom buds. As the plants developed, later infestations were confined to the lower portions of the stem and were not so easily seen. When the larvae matured the plant was chewed all the way to the top. Where infestations were heavy complete defoliation occured. Chewed leaves have an irregularly scalloped appearance. (Figs. 4 and 5) Unless the population in an area is very large and defoliation is complete, the leaves are left in this condition and present a very characteristic appearance.

It was observed that larvae in the rearing cages did not feed on the uppermost part of the plant until the last 48 hours prior to pupation. The final day was mainly spent feeding on the blossom proper. The flower was approached from the side and a hole chewed through the petal and the stamens and anthers, as well as the ovaries, were destroyed. Usually only the calyx and a small part of the blossom was left.

Fig. 4. Lowbush blueberry stems showing typical leaf damage by flea beetle larvae, natural size.(orig. photo by R. L. Coffin)

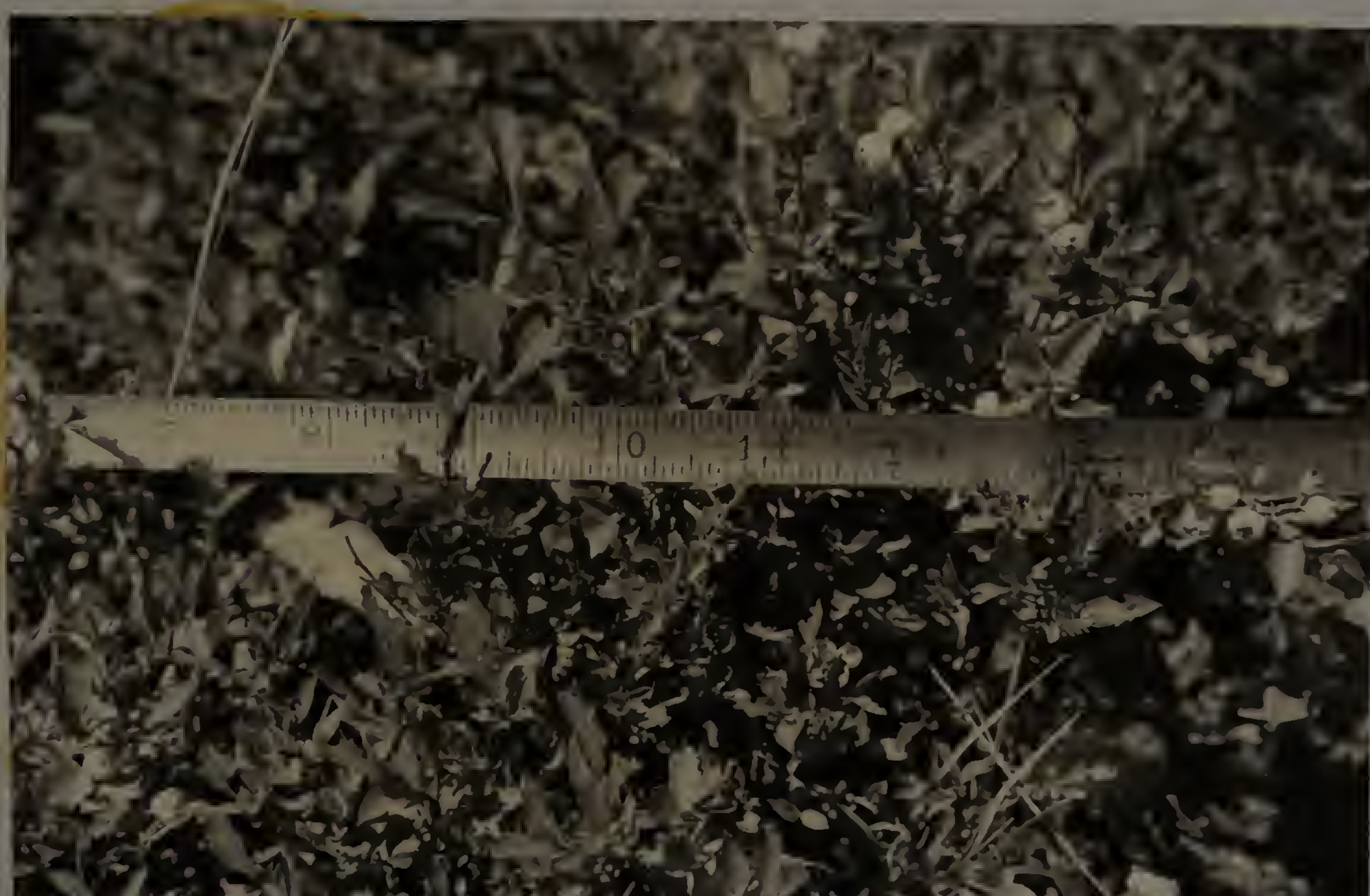

Fig. 5. Flea beetle damage as it appears in the field, about three-fifths natural size.(orig. photo by author)

Food Plant Selection

Flea beetle larvae were never found feeding more than about six inches above the ground. It may be that above that level the leaves on a plant are too old and tough for their liking. Nor were they observed upon the numerous hybrid blueberry species which range from six or eight inches to two or more feet in height, even where those plants occured in the midst of heavily infested lowbush varieties. Also, where defoliation was nearly complete on *Vaccinium pennsylvanicum*, and *V. lamarckii* the variety *V. myrtilloides* was not touched. *V. myrtilloides* has a somewhat more pubescent undersurface on the leaf and grows a few inches taller than the most common species *V. pennsylvanicum*.

Extent of Infestation

Damaged areas usually occured in discreet patches ranging in size from several square feet to 2000 square feet. On one lot near Ashburnham about four acres had been 100% defoliated. Except for certain seldom occuring types, which will be noted later, not a single leaf was to be seen. This is undoubtedly what has happened in some lots where the growers report that the plants look as though a "fire" had swept through some particular areas.

Where unburned lots which had been heavily infested the year before were visited, a definite reduction in the vitality of the growth was noticed.

Rate and Means of Migration

It was found that the larvae moved into new areas at a rate of about one foot per day under normal weather conditions. Where population density is high and there are many larvae per plant, the rate would probably be greater. The experiments conducted by clean sweeping an area and noting the rate of repopulation were done where larval numbers were not very high, and the rate of one foot per day, which was established, would probably have been increased had there been more larvae.

Several lots which had been burned over early in the year were found to contain flea beetle larvae in many of the small patches which had not been destroyed by the fire. In later inspections these larvae were found to have moved well out into the new growth as it leafed out. These observations make clear the need for getting a good burn every year to help keep the beetles in harmless low concentrations.

The adult beetles do not fly, but are capable of jumping fairly long distances. Their movement is probably sufficient to cover quite a large area in a short time. In making surveys of adult populations during June and later on, the distribution was found to be fairly uniform. This would tend to show that they move freely from one place to another in feeding.

Reactions to Environmental Changes and Molestation

Both the larvae and the adults of the blueberry flea beetle are inactive on cloudy or cool days. During such weather they seek shelter in the soil and do not feed. It was noticed that after a heavy rain the larvae were not in evidence upon the plants for two or three days.

When disturbed by the vibrations of walking in their vicinity the larvae drop to the ground and feign death. For this reason, in making sweeps, care had to be taken that the net was held well out in advance of the body, otherwise only a small portion of the actual population would have been sampled, sweeps close to the feet taking only those insects which remained clinging to the foliage. Adults show this same tendency to feign death.

Life Cycle

Woods (1918) gives the following life cycle data for the blueberry flea beetle in Maine: length of feeding period 13.5 days; prepupal period 7 days; pupal period 11 days; total developmental period 31.5 days. He found that there was one generation per year and that it over-wintered only in the egg stage.

Larvae reared by the author spent from twelve to fourteen days actively feeding. One to two day old larvae brought into the laboratory on the 25th of April began to enter the soil and construct pupal cells in the earth on the 6th of May and continued until the 7th, the first adult emerged on the 21st. Of about a dozen larvae reared from the first instar, nine survived to adulthood.

The average periods of development found by the author would be as follows: larval feeding period, 13 days; prepupal period, 7 days; and pupal period, 11.5 days; total developmental period 31.5 days.

In regard to the question of how the insects over-winter, no evidence was found which would suggest that the adults hibernate. In the screened cage beside Fernald Hall, into which a large number of adults had been placed in the fall of 1948, not a single adult was found the following spring. In the spring there were flea beetle larvae in the cage, the first of which was seen several days before those found in the field. As the cage was checked daily from early in March, it is very unlikely that there were any adults which had survived the winter and gone unobserved in the limited area covered by the cage.

Although an attempt was made to find eggs in the field by searching the soil, none were found. Nor was it possible to induce the adults to oviposit in the laboratory. Woods was successful in getting the adults to oviposit in the laboratory and defines the laying season as the end of July and the early part of August. This date would probably correspond to mid-July in Massachusetts.

The life cycle proved to be the same as it is in other parts of New England except that it begins earlier in Massachusetts than elsewhere. The larvae appear in Maine one to two weeks later than in this state. The discrepancy of 0.5 days in larval and pupal periods is probably not significant.

Experimental Control of Flea Beetle with Parathion

98% control was obtained against flea beetle larvae with both the 25% wettable powder and 0.5% dust formulations. The actual control may have been almost 100%, as the few larvae which were found on the plots after the tests may very well have migrated from the untreated areas around the periphery. Due to an oversight they were not kept for observation to see if they were poisoned, and no leaves were taken from the treated plants for tests of residues remaining. There was no visible injury to the plants.

Table one shows the results of the experiment for control with parathion. The rate of application was based on the minimum amounts which could be applied by hand methods. The larval counts were based on an average of ten sweeps.

TABLE 1

Parathion Tests For Control Of Flea Beetle Larvae

	Formulation	Rate	Count Before Application	Count At end of Three days	Mortality Percent
Plot A	0.5% dust	54 lbs. /acre	4.5/sweep	0.1/sweep	97.8%
Plot B	25% wettbl. powder 1½ lbs/100 gals.	200 gals. /acre	17.5/sweep	0.4/sweep	97.7%
Plot C	none	---	*40/sweep	*40/sweep	---

*estimated number

Mortality counts for areas treated with 5% DDT dust were made in marked areas and no tabulation of data was attempted. Where larvae were in early instars the control ran above 80%. In regions where the larvae were in more advanced instars, the apparent mortality was 50-60%. This bears out similar findings of the Maine Agricultural Experiment Station workers (1949,12).

Experimental Control of Flea Beetle with DDT

Table two shows the results of petri dish experiments to determine the efficiency of DDT against late instar larvae. Larvae used for the test were selected on the basis of size.

TABLE 2

Tests to determine effect of DDT and Arsenic on late instar larvae of Flea Beetle.

	3% DDT dust	85-15 lead-sulfur	Check
no. leaves	5	5	5
no. larvae	25	25	25
6 hrs.			
cond. of leaves	25% eaten	25% eaten	100% eaten
no. larvae alive	25	25	25
24 hrs.			
cond. of leaves	50% eaten	25% eaten	100% eaten
no. larvae alive	25	none	25
48 hrs.			
cond. of leaves	75% eaten	25% eaten	100% eaten
no. larvae alive	11	none	25
Mortality percent	56	100	0

Replicate using 5% DDT

48 hrs.			
no. larvae alive	10	2	23
Mortality percent	60	92	8

The replicate duplicated the other results obtained so they are omitted in the second half of the table.

The results obtained in this test showed that DDT had low toxicity when it was used against nearly mature flea beetle larvae. Lead arsenate and sulfur was quite effective in killing the larvae. An average of 58% of the larvae died when treated with DDT dusts, whereas lead-sulfur dust gave an average kill of 96%.

Reduction in Yield of Fruit Due to Flea Beetle Damage

The average yield from the two plots treated with Parathion was found to be much greater than the check plot. The results, calculated on a basis of number of quarts per acre, are shown in table three.

TABLE 3

Comparison of yield on treated and untreated plots where Flea beetle were present.

	Parathion 25% wettable powder	Parathion 0.5% dust	Check
Area	900 sq.ft.(Plot A)	1600 sq.ft.(Plot B	900 sq.ft.(Plot C)
Yield	11 qts.	41 qts.	4 qts.
Yield	528 qts./acre	1107 qts./acre	192 qts./acre

The average yield of the treated plots was 817 quarts per acre. The yield of the untreated plot was only 192. In comparison, the untreated plot gave only 23% as many berries as the average of the two treated plots. Therefore, the reduction of yield due to flea beetle damage in the untreated plot was 77%.

The data given in this table, however represents only an approximate calculation. When the plots were laid out it was not found practical to make a fruit bud count to forecast the potential yield of each one. Therefore, due to the natural fruit producing difference among the plants in the three plots, the only safe assumption which can be made is that flea beetles can reduce yield enough to warrant control methods.

In observing infestations about the state, the amount of fruit reduction due to flea beetle was obvious in spite of the fact that no precise survey was made in any other lots except the one represented in the table. The aforementioned case of the lot near Ashburnham is a demonstration of one hundred percent reduction in yield.

Observations made on Blueberry Maggot

The first specimens of Rhagoletis pomonella were taken on the 21st of June. They seemed to be present in fairly large numbers, the peak concentration coming in about one week. On lots which were quite weedy, the count ran higher than those on which the weeds had been kept down. Very few flies were found after the middle of July.

Several of the adults were seen ovipositing on the 30th of June, and again on the 5th and 9th of July. Harvesting of the fruit began about the 15th of July.

From random samplings of packaged fruit ready for market in the cleaning and packing sheds, maggot infestations of from 0.5% to 7% were found. The heavier infestations were found in the northern part of the state where berries had received more rainfall and were presumably juicier and riper than those in the less humid southern region. The 1949 growing season was marked by a serious rainfall shortage, especially in the southern part of the state.

The "half-high" hybrid blueberries, which have a larger, darker fruit and ripen somewhat earlier than the lowbush, were much more heavily infested. Maggots were found in up to 35% of the berries from these plants. These "half-high" berries are not usually harvested because of their dark color and early ripening. Regardless of their color, it is not economical to pay pickers for early harvesting of these berries because the average lot does not contain enough of them to make it worthwhile. These plants would seem to create a good trap crop for blueberry maggots.

In lots where there were many weeds the number of adults taken and the percentage of maggoty berries was greater than in those lots where the weeds were fewer. Lots which are periodically burned show fewer maggots for this reason. These patches of weeds may offer shelter for the adults, and in many cases, breeding sites and protection for the pupae.

ANNOTATED LIST OF INSECTS COLLECTED ON LOWBUSH BLUEBERRY

The insects noted in the following section are those which were collected during the course of the summer's work. Several species were collected in such small numbers that they were considered as accidental visitors. Species known to be important blueberry pests are included regardless of the frequency of their occurence. An asterisk indicates a species not reported to have been taken on lowbush blueberry before.

Orthoptera:

*Chortographa viridifasciata (DeGeer). This species was taken occasionally during the summer but was never found in very large numbers, the common name is northern green-stripped locust.

*Oecanthus niveus DeGeer. Although primarily an arboreal species this insect, known as the "snowy tree-cricket", was taken on blueberry several times. They were probably feeding on the leaves. It is a pale green, delicate creature, with gossamer wings, 18 mm. in length.

Pardalophora (Hippiscus) apiculata (Harris). Called the "coral-winged locust", this grasshopper was very numerous in the blueberry fields. The nymphs were taken feeding on leaves of the lowbush blueberry throughout the spring and mid-summer. In July and August the adults became very conspicuous as they spread their brilliantly colored hind wings in flight when they were disturbed. The adults are about 50 mm. long.

Hemiptera:

Adelphocoris rapidus Say. This Mirid bug was present as adults in moderate numbers from June on into the summer, it was found in both the dark and the light brown color phases. The light brown phase has a red area on the apex of the cuneus. Phipps (1930) records it from Maine. They are about 8 mm. long.

*Banasa dimidiata (say). Phipps collected this Pentatomid on highbush blueberry both in Maine and Massachusetts. It is a species about 12 mm. in length, varying in color from olive to reddish-brown. The tip of the scutellum is whitish. Adult specimens were taken on lowbush by the writer. The first specimen identified was collected on the 31st of May.

Chlorochroa uhleri Stal. Also reported by Phipps, this large, green "stink bug" was one of the most numerous members of the order taken. The nymphs apparently feed on the plant juices before the berries ripen, then turn to sucking the juice from the fruit as they mature. In several lots they were very abundant. The moult to the adult form occured at about the time of harvest, or sometime during mid-July.

When these insects feed they leave a decided odor and taste where they have been. Many berry samples tasted were almost unpalatable due to the bad taste given to them by the bug. If one happens to be confined in a box of blueberries intended for the market, the whole box may be ruined. Because of the large numbers of these stink bugs present on one of the fields which had been sprayed for flea beetle, it may be assumed that they begin their nymphal life after the period when it is necessary to treat for the beetle. Length is 15 mm.

*<u>Euschistus</u> <u>variolarius</u> (Palisot de Beauvois). A close relative to <u>E</u>. <u>euschistoides</u> (Voll.) taken by Phipps, this brown "stink bug" follows much the same developmental period as does the previous species. Although not present in great abundance, they presumably contribute to the amount of off-taste berries. Length is 12 mm.

*<u>Ischnorhynchus</u> <u>resedae</u> (Panzer). This is a medium sized lygaeid bug about 6 mm. long. They are a reddish-brown color with the wing membranes transparent and colorless. Specimens were collected frequently during June.

<u>Lygaeus</u> <u>Kalmii</u> Stal. A brightly marked red and black bug of the Lygaeid family, this species was observed copulating on the blueberry plants in the late summer. It is commonly found on milkweed in many parts of the United States. According to Phipps, it is also found on blueberries in Maine.

*<u>Mormidea</u> <u>lugens</u> (Fab.). The first specimens of this Pentatomid were taken in June, when it was quite common. It is conspicuously marked with a whitish border margining the free edges of the scutellum. The remainder of the body is a dark brown. Length is about 6 mm.

*_Phlegyas abbreviatus_ (Uhler). Closely allied to the "chinch bug", this is a brachypterous form. During June and July it was extremely numerous, many specimens being taken with each sweep of the net. The pronotum and elytra are light brown and the rest of the body is dark brown. Length is 3 mm.

Homoptera:

Clastoptera proteus Fitch. The "cranberry spittle bug" Franklin (1948) regards this as major pest of cranberries in Massachusetts. Phipps (1930) has also observed this spittle bug in Maine. He mentions that it is frequently found on low-bush blueberry and has seen it ovipositing in the stems of the plants.

It was present in moderate numbers from mid-summer on into the fall. No more than 5 mm. long, it is marked with three transverse yellow lines on the pronotum, and two longitudinal yellow lines on the elytra.

*_Gypona cinerea_ Uhler. This is a leaf hopper about 10 mm. in length. The specimens which were identified were taken on the 30th of June. The color is a medium brown with several black spots on the membrane of the wings and it is mottled overall with dark red spots. It was only taken occasionally.

*_Gypona scarlatina_ Fitch. This and the preceeding species are very much alike. It is a light brown with dark red mottling covering the whole dorsal surface. The time and frequency of occurrence are the same as _G. cinerea_.

Lepyronia quadrangularis Say. Although not numerous, this "spittle bug" was usually found in most lots. It is about 8 mm. long. The ground color is a light chocolate brown, two darker bands on each fore-wing joining at the mid-line to form a diamond.

**Philaenus spumarius* species. This is a member of a variation group and could not be identified past the principal species. During June and July it was very common. The frons and the anterior half of the pronotum of this spittle bug are a tawny yellow. The remainder of the dorsum is pale with a brownish patch on the sides of the fore-wings. Length is 6 mm.

**Xerophloea major* Baker. Of a uniform green color with clear wings, this leaf hopper is about 8 mm. long. It was not very numerous. A number of specimens were collected on the 31st. of May.

Coleoptera:

**Anthonomus musculus* Say. Where highbush blueberries are grown, this is an important pest known as the "blueberry blossom weevil". Franklin (1928) records it as a minor pest of cranberries. Phipps reports it from Maine on highbush blueberry. No references to attacks on lowbush were found in the literature reviewed.

In the early part of May a considerable number of these tiny (2.5mm.) weevils were found feeding on the unopened blossoms of lowbush blueberries. Evidences of its feeding were reported to the author as early as the 25th of April.

The adult beetles emerge from hibernation in the spring and feed on the unfolding blossoms for several days. After this feeding period they oviposit in the blossoms. The only external sign of their work is a small puncture in the side of the blossom. The larvae develop inside of the blossom and remain there as the fruit begins to form.

Several live specimens were brought into the laboratory and placed on caged plants. They fed normally, but because the plants died, no data was obtained on the larvae.

*<u>Anthonomus</u> <u>rubidus</u> Lec. Several specimens of this weevil were collected near Westhampton feeding in the same manner as the above species in the same areas where that species was found. It is a mahogany red beetle slightly larger than <u>A. musculus</u>, which is dark brown with a few white scales on the elytra. No previous record of this insect feeding on <u>Vaccinium</u> species is known to the author.

*<u>Cardiophorus</u> <u>convexulus</u> Lec. The scutellum of these small black click beetles is heart shaped, as the generic name would indicate. They are shiny black and from 8 to 10 mm. in length.

From the first collecting trip in April to the last one in late August, these beetles were present in great numbers in nearly all the lots visited. They may cause great damage to the root systems of the blueberries.

<u>Chlamys</u> <u>plicata</u> <u>Fab</u>. Phipps records this interesting case bearer as being common on new-burned fields in Maine. Several of the curiously sculptured adults were brought to the author

in June. They are only 3 mm. long and metallic blue colored. The body form is quadrate and very robust.

*Chrysodina globosa (Oliv.). Next to the blueberry flea beetle this species was the most prevalent Chrysomelid beetle found in the course of this work. They were present from April into the latter part of the summer. The color is dark brassy green on the dorsal surface and the legs are reddish brown. The body form is almost round when viewed from above and the dorsum is so strongly curved that the insect is almost hemispherical in shape. The length is about 3 mm.

*Graphops curtipennis Melsh. A number of these very small leaf beetles were taken in May. They are metallic blue and no more than 2 mm. long.

Haltica sylvia Malloch. The blueberry flea beetle.

*Paria canella (Fab.) A common pest of strawberries known as the "strawberry root worm", this beetle was first found in the cage plot beside Fernald Hall on April 22nd. Subsequently, it was taken in the blueberry lots later in the season. They were never present in great numbers.

Lepidoptera:

*Abbotana clemataria (S. & A.). Franklin (1928) records this species as an important pest of cranberries. Known as the "big cranberry spanworm", it is herein reported for the first time on lowbush blueberry.

The larvae were found in large numbers on one lot near

Granville in particular. When first noticed on the 9th of June, these larvae were only about 10 mm. long and wholly black. One of the larvae brought back for rearing survived long enough to pupate on the 14th of July. The pupa was attacked by fungus and did not emerge.

The period of development corresponds very closely with its cycle on cranberry. Franklin states that hatching occurs in mid-June and pupation takes place in July. There is only one generation a year.

When full grown the larvae is a rich chocolate brown. The maximum size of the specimen reared was 50 mm. They assume a rigid attitude when resting and resemble a dry twig. The illusion is heightened by a pair of knobby dorsal tubercles.

The moth is buff colored with light brown markings on both wings. The wing tips are attenuated and curved. One day during the end of May many of these moths were observed flying in the blueberry fields. They were very ragged, probably the overwintering adults which had survived to foster the infestations found later.

Cingilia catenaria Drury. This is an important pest of lowbush blueberries which sporadically appears in tremendous numbers in Maine, Phipps (1928), and in Canada, Maxwell and Pickett (1949).

Only two specimens of this insect were collected during the summer. Both were larvae. These larvae are yellowish with prominent black spots along the sides. When fully grown they are about 45 mm. long. The moths have white wings with a zigzag black line in from the outer margin.

Drasteria graphica atlantica B. and McD. The larvae of this moth were very numerous in July. They are purple striped, about 50 mm. long when full grown. A day flying Noctuid with bright orange hindwings, the adults were taken freely during the month of June. During the first part of the month they were swarming by the thousands. Phipps reports a heavy outbreak of the larvae of these moths. He states that even the green berries and the bark of the lowbush blueberry were stripped.

Euchlena serrata Dru. This is a large Geometrid moth the larvae of which are a uniform light gray color. Phipps collected one specimen feeding on lowbush blueberry.

Several of the larvae were collected during May, one of which developed into a handsome moth with a yellow body and yellow wings banded with brown. The wing span is about 35 mm.

Epiglea apiata (Gr.). Franklin calls this the "cranberry blossom worm". It is sometimes a serious early-season pest in the cranberry bogs.

Several of the larvae of this cutworm were swept from lowbush blueberry plants during the early part of May. The full grown larva is about 35 mm. long. The dorsum is reddish-brown and there is a white lateral stripe. Below the lateral stripe the color is pink.

Gelechia (Aroga) trialbamaculella Chambers. This is another of the major pests of cranberry. Franklin gives it the common name "red striped fireworm".

Many fields in the northern part of Massachusetts were found to be heavily infested with this insect. The larvae bind the terminal leaves of the plant together with webbing and mine the new growth. The moths, which are brown with a sprinkling of white spots on the wings, span about 15 mm. with the wings spread. The larvae are pale green with lateral red stripes. They were observed in the larval stage during late July and on into August. Franklin states that there may be two generations a year with the later generation overwintering as pupae.

Glena cognataria Hbn.? From descriptions given by Phipps it is believed that this species of looper was the one which occured in great numbers in some of the lots under observation.

The first generation appeared during the middle of June. Larvae brought into the laboratory on the 21st of that month had all pupated by the 24th. The adults began to emerge on the 7th of July. A second generation was observed in August. Seven larvae collected on the 25th of August had all pupated by the 8th of September. None of these emerged. This second generation probably hibernates as a pupa. The larvae are mahogany colored with whitish spiracles. The moths are about 18 mm. in wing span and are light gray.

Itame inceptaria Walker. (Itame argillacearia). (Diastictis inceptaria). Slingerland (1897) describes heavy infestations of this looper in New Hampshire. McDonnough (1924) reports it from Canada, but at that time was not sure it fed on blueberry. Lathrop (1936) reports them in Maine, and O'Kane and Conklin (1937) report them again in New Hampshire. Its' attacks take place very infrequently, the 1937 attack in New Hampshire is mentioned as being the first one since the one recorded by Slingerland in 1897.

In view of the above facts, it was very surprising to find this "blueberry looper" very common throughout the state during May and June. It was present in some lots in numbers great enough to be considered a major outbreak.

The larvae are about 30 mm. long when full grown. The general ground color is mainly white and the spiracles and chalazae are black. The mid-dorsal line is light yellow as are the lower portions of each of the segments. The head is mostly black. The moths are plain gray with faint darker spots on the costal margin of the wing. The wings span about one inch.

*Itame sulphurea (Pack.). A common cranberry pest called the "green cranberry spanworm", this moth was abundant in June. The larvae are pale green with six longitudinal white lines running the length of the body. When mature they are about 30 mm. long.

The buff colored moth is about one inch wide with dark mottling on the costal margin of the wings.

Porthetria dispar L. Several gypsy moth larvae were found feeding on blueberry in widely separated locations.

Diptera:

Rhagoletis pomonella Walsh. The blueberry maggot.

Thysanoptera:

Frankliniella vaccinii Morgan. The blueberry thrips. Very occasionally found. No concentrated populations were found anywhere in the state.

SUMMARY

During the summer of 1949 about one half the total acreage of lowbush blueberry lots in the state was visited. The most prevalent and damaging insect present was the blueberry flea beetle. Besides the blueberry flea beetle, the blueberry maggot was also found widespread throughout Massachusetts. The results of the summer's work may be summarized as follows:

1. Parathion used as a dust and a spray gave very good control of all stages of the blueberry flea beetle, but DDT gave inferior results when used against larvae which were in late instars. A lead arsenate and sulfur dust gave good control in a small scale test.

2. Crop reduction due to blueberry flea beetle damage varied from light to heavy in different lots. In the plots which were closely measured for yield data, the yield on an untreated area was only about one quarter that of the treated areas.

3. In the screened plot beside Fernald Hall, no adults were found in the spring and none were collected in the field until after the larval outbreak in May.

4. Adults of the blueberry maggot were found in all areas. Where the ripe fruit was inspected for the larvae, the infestation rate ran from 0.5 to 7% maggoty. Lots which had not been recently burned or contained a large number of weeds had more maggoty fruit.

5. 35 other species of insects were found present on lowbush blueberry. Two beetles, *Cardiophorus convexulus*, and *Chrysodina globosa* were very common. Lepidoptera present in numbers sufficient to warrant concern were *Abbotana clemataria*, *Drasteria graphica atlantica*, *Itame inceptaria*, *Itame sulphurea*, and *Gelechia trialbamaculella*. Of the Hemiptera, the "green stink bug", *Chlorochroa uhleri*, and a "chinch bug", *Phlegyas abbreviatus*, were the bugs most often found. The "cranberry spittle bug", *Clastopera proteus*, was taken very frequently.

CONCLUSIONS

The blueberry industry of Massachusetts is very sorely beset by insect pests. Beside the blueberry flea beetle and the blueberry maggot, there are at least ten other species of insects which seriously damage the crop. A great deal of work is needed to establish adequate control methods for these insects.

Parathion is superior to DDT in eliminating flea beetle damage, and arsenicals are probably also superior. The principal drawback to the use of arsenate insecticides is, of course, the residual properties of that insecticide.

One of the primary factors in controlling the blueberry flea beetle is the matter of finding the outbreak of larvae in time on large lots. Where possible, it would be advantageous to make bi-weekly inspections of the blueberries during the period when they are likely to become abundant. Outbreaks may occur at any time beginning in late April into early June.

Such practices as frequent burning of lots and weed control methods should tend to reduce the population of the blueberry maggot. Clean picking and destruction of nonmarketable berries during the harvest season is also essential to controlling the maggot.

It is the belief of the author that the annual yield of blueberries in this state could be almost doubled if the proper program were ultimately devised and adhered to by the growers.

BIBLIOGRAPHY

(Anonymous). Blueberry insects.
1942. (in) Me. Agric. Exp. Sta. Bul. 411:262-263, tbl. 5, fig. 10.

1945. (Blueberry notes). (in) Dom. of Can. Dept. of Agric. Processed Pub. No. 19:5.

1946. Small fruits. (in) Me. Agric. Exp. Sta. Bul. 442:280-281.

1947. Blueberry dust program for 1947. Me. Exten. Circ. 231:1-4.

1949. (in) Blueberry research and service. Me. Agric. Exp. Sta. Misc. Pub. 614:10-12.

Beckwith, C.S. Insects attacking blueberry fruit.
1943. N. Jersey Agric. Exp. Sta. Circ. 472:1.

Blatchley, W. S. Coleoptera of Indiana.
1910. Nat. Pub. Co., Indianapolis, Ind. pp. 1385, map 1, figs. 1-590.

1916. and C. W. Leng. Rhynchophora or weevils of North Eastern America. Nat. Pub. Co., Indianapolis, Ind. pp. 682, figs. 1-155.

1926. Heteropera or true bugs of Eastern North America. Nat. Pub. Co., Indianapolis, Ind. pp. 1116, pl. XII, tbl. 1, figs. 1-215.

Camp, W. H. The North American blueberries with notes on
1945. other groups of Vacciniaceae. Brittonia 5 (3):203-275, figs. 1-30.

Darrow, G. M., R. B. Wilcox and C. S. Beckwith. Blueberry
1946. growing. U.S.D.A. Farm. Bul. 1951:4-6, 34-38, figs. 22-23.

Fall, H. C. On certain species of Haltica, old and new.
1920. Psyche 27:101-107.

Franklin, H. J. Cape Cod cranberry insects.
1928. Mass. Agric. Exp. Sta. Bul. 239:1-67, figs. 1-68.

1948. Cranberry insects in Massachusetts.
Mass. Agric. Exp. Sta. Bul. 445:1-64,
figs. 1-68.

Hawkins, J. H. Black army cutworm. (Actebia fennica
1947. Tauscher).
Me. Agric. Exp. Sta. Bul. 449:423-425,
figs. 16-18.

Lathrop, F. H. (Blueberry notes).
1936. (in) Me. Agric. Exp. Sta. Bul. 384:333-334,
431-432.

1942. The blueberry thrips.
J. Econ. Ent. 35:198-201, figs. 1-3.

1944. B. E. Plummer and C. O. Dirks. Small fruits.
(in) Me. Agric. Exp. Sta. Bul. 426:327-328,
tbl. 55.

1945. Small fruits.
(in) Me. Agric. Exp. Sta. Bul. 438:652-654,
fig. 2.

1946. and J. H. Hawkins. (Blueberry notes).
Me. Agric. Exp. Sta. Bul. 442:280-281.

1947. Blueberry fruit fly. (Rhagoletis pomonella
Walsh).
(in) Me. Agric. Exp. Sta. Bul. 449:427.

1947A. Blueberry thrips. (Frankliniella vaccinii
Morgan).
(in) Me. Agric. Exp. Sta. Bul. 449:426, fig. 19.

1947. and F. B. Knight. Blueberry flea beetle.
(Haltica sylvia Mall.).
(in) Me. Agric. Exp. Sta. Bul. 449:425.

1948. et al. (Blueberry notes).
(in) Science serves Maine agriculture.
(in) Me. Agric. Exp. Sta. Bul. 460:10-11.

1949. Maine blueberry dust schedule.
(in) Blueberries, insect and weed control, bees
as pollinators.
Me. Exten. Circ. 255:2-5.

Malloch, J. R. Notes on some species of the Chrysomelid
1919. genus Altica (Coleoptera).
Bul. Brook. Ent. Soc. 14:123-124.

Maxwell, C. W. and A. D. Pickett. Blueberry insects and
1949. their control in the Maritime provinces.
(in) The blueberry.
Dom. Dept. of Agric. (Canada). Pub. 754:26-29.

McDunnough, J. C. Notes on the Ribearia group of the
1924. genus Itame (Lepidoptera).
Can. Ent. 56:271-277, pl. 6.

Patch, E. M. and W. C. Woods. The blueberry maggot in
1922. Washington county.
Me. Agric. Exp. Sta. Bul. 308:78-92, fig. 2.

Phipps, C. R. The black army cutworm.
1927. Me. Agric. Exp. Sta. Bul. 340:201-216, figs. 29-30.

1928. The chain-dotted measuring worm.
Me. Agric. Exp. Sta. Bul. 345:33-48, figs. 6-7.

1930. Blueberry and huckleberry insects.
Me. Agric. Exp. Sta. Bul. 356:1-232, tbls. 1-4.
figs. 1-24.

Shaw, F. R. Unpublished manuscript. (Univ. Massachusetts ?)
1948.

Slingerland, M. V. The blueberry spanworm (Diastictis
1897. inceptaria).
Can. Ent. 29:49-52.

Woods, W. C. The biology of Maine species of Altica.
1918. Me. Agric. Exp. Sta. Bul. 273:149-204, figs. 10-13.

1924. Part two. Economic and biological.
(in) The blueberry leaf beetle and some of its
relatives.
Me Agric. Exp. Sta. Bul. 319:93-105.

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